4. RESULTS AND DISCUSSION

The obtained results of the dual relationship between the responses of sugar beet yield and its quality on one hand and calcareous soil supply with some macro or micronutrients, i.e., K, Zn and B on the other hand were discussed under the following sub-headings.

4.1. Dry weight of sugar beet leaves as affected by K, Zn and B application:

Effects of different K rates added alone or combined with Zn and B ones under the applied two methods of soil application or foliar spray on the dry weight of sugar beet leaves are given in Tables (2 and 3) and illustrated in Fig. (1). Data indicate that the applied K, Zn and B either added alone or together had marked effects on dry weight of sugar beet leaves at 100 days from planting. However, increasing the applied K rates added alone up to 40 kg K/fed and 1000 mg K/L, respectively, consistently increased dry weight of leaves. The greatest growth of sugar beet leaves was found at the highest rates of both applied methods, with corresponding relative increases of 18.18 and 31.43 %, respectively.

Table (2): Effect of K, Zn and B as soil application on dry weight of sugar beet leaves after (g/plant) 100 days from planting.

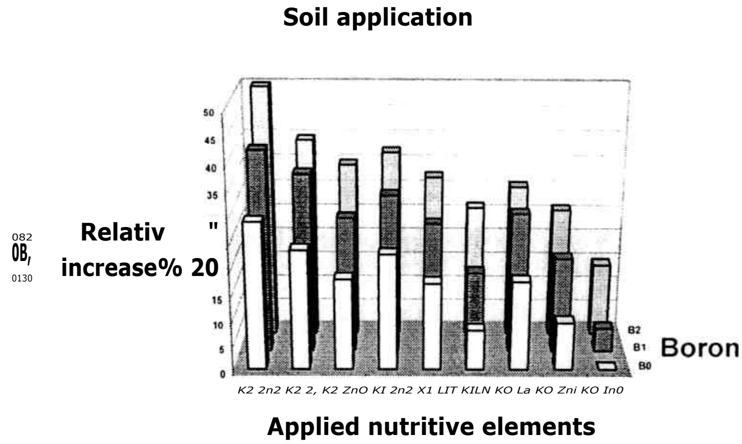
K (k/fed)	Zn (kg/fed)	B (kg/fed)			Mean
		0.0	1.0	2.0	
0	0.0	27.93	29.28	32.00	29.96
	3.5	30.64	33.25	35.16	33.02
	7.0	32.90	35.74	36.45	34.98
Mean		30.71	32.76	34.49	32.65
20	0.0	30.19	32.45	35.27	32.64
	35	32.80	35.17	36.98	34.98
	7.0	34.37	36.75	38.33	36.48
Mean		32.45	34.79	36.86	34.70
40	0.0	33.01	35.50	37.64	35.38
	35	34.60	37.88	39.00	37.16
	7.0	36.10	39.14	41.87	39.04
Mean		34.57	37.51	39.50	37.20

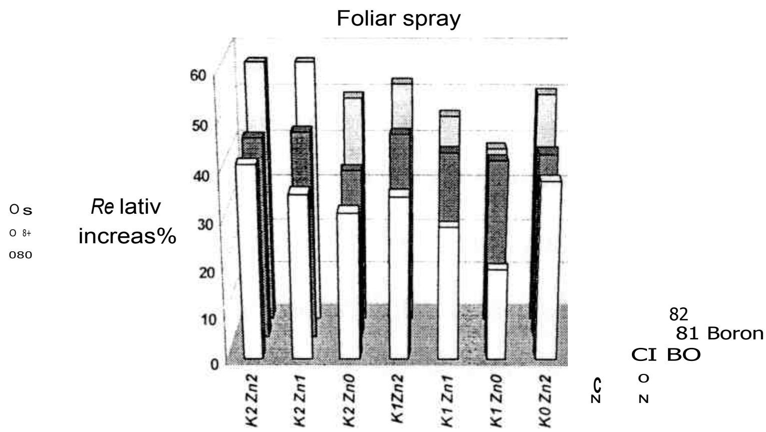
L.S.D. at 0.05						
K	Zn	B	KxZn	KxB	ZnxB	KZnB
0.29	0.30	0.30	0.33	0.33	0.33	0.16

Table (3): Effect of K, Zn and B as foliar spray on dry weight of sugar beet leaves after (g/plant) 100 days from planting.

K (mg/L)	Zn (mg/L)	B (mg/L)			Mean
		0	35	70	
0	0.0	27.93	32.41	35.15	31.83
	100	33.38	36.49	38.51	36.13
	200	36.35	39.21	41.85	39.14
Mean		32.55	36.04	38.50	35.70
500	0.0	33.32	35.75	38.55	35.87
	100	35.83	39.32	40.55	38.53
	200	37.70	40.30	42.46	40.15
Mean		35.62	38.42	40.52	38.18
1000	0.0	36.71	38.17	41.61	38.83
	100	37.79	40.43	42.75	40.32
	200	39.54	40.16	43.75	41.72
Mean		38.01	42.70	40.58	40.29

L.S.D. at 0.05						
K	Zn	B	KxZn	KxB	ZnxB	KZnB
0.052	0.037	0.041	0.037	0.041	0.041	0.059





Applied nutritive elements

Fig. (1): Relative increase of dry weight (%) in sugar beet leaves after 100 days due to application of K, Zn and B at different rates.

These data mean that K foliar spray was more effective for increasing the growth of sugar beet leaves as compared to soil application method. These increases in the growth of sugar beet leaves, due to addition of K as soil application and foliar spray, are mainly attributed to the role of K in plant growth. These results are resembled with those obtained by **Osman (2005)** who concluded that potassium fertilizer plays an important role in physiological processes in sugar beet plants, where it significantly increased total dry weight of sugar beet leaves.

Similarly, addition of Zn as soil application and foliar spray to the studied calcareous soil increased the dry weight of sugar beet leaves. Also, the best treatment was achieved in case of the highest applied rates, i.e.., 7 kg Zn/fed and 200 mg Zn/L added as soil application and foliar spray, respectively. However, the corresponding relative increases in growth of sugar beet leaves as a result of Zn application at rates 7 kg Zn/fed and 200 mg Zn/L as soil application or foliar spray were 17.79 and 30.15 %, respectively. The relative increase in case of Zn-soil application may be due to slight reduction in soil pH caused by the application of Zn in the form of sulphate, and in turn increasing the availability of Zn.

These results are in agreement with those obtained by **Fathi *et al.* (1983)** who found that growth yield increased by mineral application of $ZnSO_4$. Also. **Elwan *et al.* (2001)** indicated that the applied Zn was more affective on total fresh and dry weights of sugar beet leaves. Data also revealed that addition of Zn as foliar spray was more effective in increasing the growth of sugar beet leaves as compared to soil application method, presumable due to its easily absorption and translocation as well as the physiological role of Zn in plant growth.

Likewise, addition of B as soil application or foliar spray increased the dry weight of sugar beet leaves, with the treatments of 2 kg B/fed and 70 mg B/L, of the best effect. The corresponding relative increases were 14.57 and 25.85 %, respectively. In this connection, **Abd El-Aziz *et al.* (1992)** and **Mahmoud (1999)** found that increasing supply of B fertilizer either as soil application or foliar spray increased the dry weight of sugar beet. Also **Hussein (2002)** found that application of B to the soil significantly increased dry weight, which accounts for 230.36 % as compared with the control treatment.

Also, data show that addition of B as foliar spray was more effective in increasing dry weight of sugar beet leaves than its addition as soil application. Moreover, addition of K at different rates in combination with Zn or B as soil application or foliar spray gave the highest increase in the dry weight of sugar beet leaves. The greatest growth was, generally, obtained at the applied highest rates of these fertilizers. The highest leaves dry weight was achieved in case of soil application at combined the treatment (40 kg K/fed + 7 kg Zn/fed + 2 kg B/fed). The corresponding relative increase in the dry weight of sugar beet leaves due to applying the previous combined treatment (as soil application) reached 49.9 % over the control. The corresponding relative increase in dry weight of leaves in case of foliar spray for the combined treatment (1000 mg K/L + 200 mg Zn/L + 70 mg B/L) was 56.6 %.

This is mainly ascribed to increasing the availability of K, Zn and B as essential nutrients for plant growth. Similar results were also observed by **Omran *et al.* (2002)** who showed that dry weight of sugar beet leaves was increased as a result of Zn-B added as either soil application or foliar spray.

It could be concluded that the growth of sugar beet grown on a calcareous soil was enhanced by the application of K in combination with Zn and B at the tested highest rates, particularly when they were added as foliar spray. This was true, since such nutrients were more available and transported in the plant tissues when applied as foliar spray as compared to soil application method. This is mainly attributed to the synergestic effect of K, Zn & B when applied as foliar spray.

4.2. Zn and B concentrations in sugar beet leaves as affected by the applied K, Zn and fertilizers:

Data in Tables (4 and 5) and Figs. (2 and 3) show that the addition of different rates of K, Zn and B to the studied calcareous soil as soil application or foliar spray caused marked effects on Zn and B contents in sugar beet leaves. It is clear that the addition of K, Zn and B as soil or foliar spray whether as solely or together resulted in increases for Zn and B contents in sugar beet leaves. The corresponding relative increases in their concentrations at the applied K rate of 40 kg K/fed were 66.6 and 50.00 % over the control treatment, respectively.

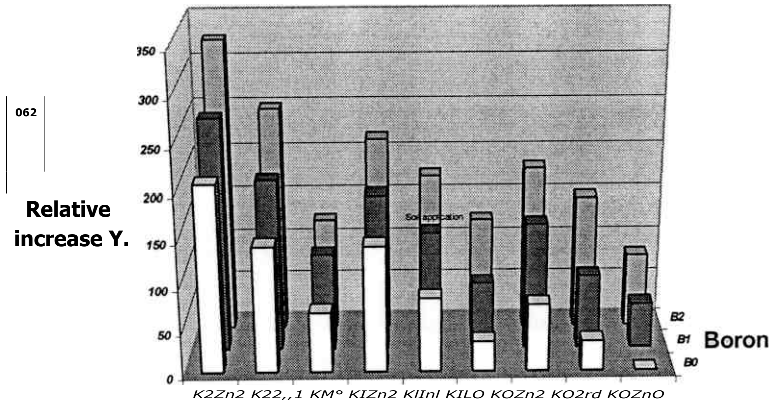
Table (4): Effect of K, Zn and B as soil application on Zn and B concentrations in sugar beet leaves after 100 days from planting.

K (kg/fed)	Zn (kg/fed)	Zn content (Kg/fed)				B content (Kg/fed)			
		B (kg/fed)							
		0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
0	0.0	12	18	22	17	20.	27	30	26
	3.5	16	22	30	23	23	29	34	29
	7.0	21	29	34	28	26	34	38	33
Mean		16	23	29	23	23	30	34	29
20	0.0	16	21	27	21	26	31	37	31
	3.5	22	28	33	28	30	35	41	35
	7.0	29	33	38	33	34	40	49	4I
Mean		22	27	33	27	30	35	42	36
40	0.0	20	25	30	25	30	36	41	35
	3.5	29	35	42	35	34	43	49	42
	7.0	37	43	51	43	55	59	67	60
Mean		29	34	4I	35	40	46	52	46
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		1.31	1.94	1.94	2.17	2.47	2.13	2.13	2.38
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		2.17	2.17	3.12		2.38	2.38	3.42	

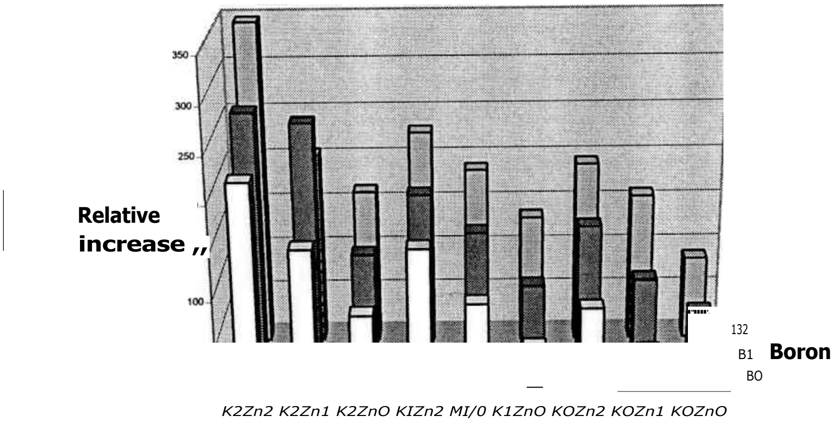
Table (5): Effect of K, Zn and B as foliar spray on Zn and B concentrations in sugar beet leaves after 100 days from planting.

K (mg/L)	Zn (mg/L)	Zn content (mg/kg)				B content (mg/kg)			
		B (mg/L)							
		0.0	35	70	Mean	0.0	35	70	Mean
0	0.0	17	26	32	25	20	37	41	33
	100	23	32	44	33	31	40	47	39
	200	31	42	50	41	35	46	52	44
Mean		24	33	42	33	29	41	47	39
500	0.0	24	31	40	32	35	43	50	43
	100	32	41	49	41	41	48	56	48
	200	42	48	56	49	47	55	66	56
Mean		33	40	48	40	41	49	58	49
1000	0.0	30	37	45	37	41	49	56	49
	100	42	61	52	52	47	59	63	57
	200	54	63	76	64	75	81	92	83
Mean		42	50	61	51	54	63	71	63
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		23.51	1.82	1.82	2.04	4.36	2.58	2.58	2.88
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		2.04	2.04	2.92		2.88	2.88	4.16	

Soil application

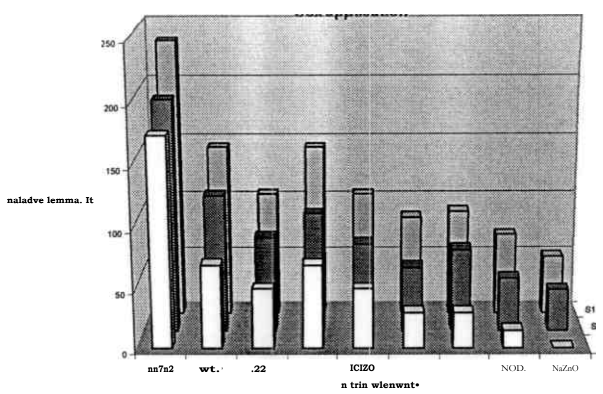


Applied nutritive elements



Applied nutritive elements

Fig. (2): Relative increase of Zn concentration (%) in sugar beet leaves after 100 days due to application of K, Zn and B at different rates.



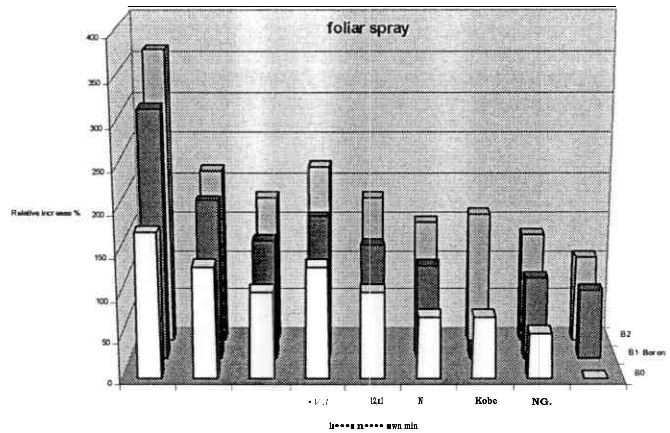


Fig. (3): Relative increase of B concentration (%) in sugar beet leaves after 100 days due to application of K, Zn and B at different rates.

On the other hand, the relative increases in Zn and B concentrations when K fertilizer was applied at the rate of 1000 mg/L as foliar spray were more than those found at the rate of 40 kg K/fed as soil application, where their relative increases were 76.5 and 105.0 %, respectively. This might be attributed to the more easily absorption of K as well as the effective role of applied K as foliar spray on enhancing the sugar beet plants to uptake more Zn and B.

These results are in accordance with those obtained by El-Aziz ***et al.*** (1992) showed that increasing K level was associated with an obvious increase in K content of tops of sugar beet. Moreover, **Eisa (2006)** found that addition of $ZnSO_4$ as soil application alone at different rates increased sugar beet leave contents of Zn and B. The corresponding relative increases reached 75.0 and 30.0 % over the control treatment, respectively.

Moreover, application of K in combination with Zn and B had a marked stimulatory effect on Zn and B contents in sugar beet leaves. In general, the highest values of each nutrient were obtained at the highest rates of applied K in combination with the highest rates of Zn and **B.**

This was true, since the applied fertilizers of K, Zn and B when added as soil application (40 kg K/fed, 7 kg Zn/fed and 2 kg B/fed) caused relative increases of 325.0 and 235.0 % for Zn and B, respectively. While, these increases were 347.1 and 360.0 % when the plants were sprayed with K, Zn and B at the rates of 1000 mg KJL, 200 mg Zn/L and 70 mg B/L, respectively.

Also, data showed that application of B to sugar beet plants grown on a calcareous soil, whether through soil application or foliar spray, gradually increased Zn and B concentrations in sugar beet leaves. The corresponding relative increases when B was applied at the highest rates as soil application and foliar spray (2 kg B/fed and 70 mg B/L, respectively) were (83.3 & 50.0 %) and (88.2 &105.0 %) for (Zn and B), respectively.

These results agree along with those obtained by **El-Shafei (1991)** who found that application of 0.5 kg B/fed resulted in a significant response for B content and uptake of top of sugar beet plants. Moreover, application of boron fertilizer significantly affected Zn content and uptake in sugar beet top at age of 120 days.

In this connection, Wrobe (1997) mentioned that boric acid application increased B concentration in sugar beet leaves.

From the previous data, it is clear that addition of K in combination with Zn and B at the applied highest rates as foliar spray was more effective in increasing the leaves contents of Zn and B in sugar beet than those added as soil application. This might be attributed to the enhancing effect of the highest applied rates of K, Zn and B fertilizers as foliar spray on plants uptake of more Zn and B. Abd-El-Aziz *et al.* (1992) found that increasing applied B as soil or foliar spray markedly increased B content in tops of sugar beet. Tariq *et al.* (1993) reported that the application of B increased B content in sugar beet leaves at mid season stage, where a positive correlation was observed between applied B level and B content in sugar beet leaves.

Moreover, Domska (1996) found that sugar beet given 100-140 kg N/ha added as soil application in combination with 0.6 kg B/ha used as foliar spray gave the highest shoot B content.

Wrobel (1997) studied the effect of some micronutrient fertilizers including Zn and B on sugar beet yield and its contents of both nutrients. He found that mean yields of roots increased with B fertilization. Also, the applied micronutrients increased B and Zn contents in sugar beet leaves. **Eisa (2006)** found that boron content in the tops of sugar beet plants was significantly increased by increasing the applied boron levels.

4.3. N, P and K concentrations in sugar beet leaves as affected by the applied K, Zn and B fertilizers:

Data presented in Tables (6 and 7) and illustrated in Figs. (4, 5 and 6) reveal that addition of K combined with Zn and B to sugar beet plants grown on a calcareous soil stimulated the plant growth, and consequently increased the uptake of N, P and K. However, addition of K alone at the highest rate (40 kg K/fed) to the soil significantly increased N, P and K concentrations in the leaves of sugar beet. These increases reached 18.2, 11.4 and 17.2 % for N, P and K over the control treatment, respectively. Also, addition of Zn at the rate of 7 kg/fed alone increased the concentrations of N, P and K by 17.8, 17.1 and 20.8 %, respectively.

K (kg/fed)	Zn (kg/fed)	B (kg/fed)											
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Mean
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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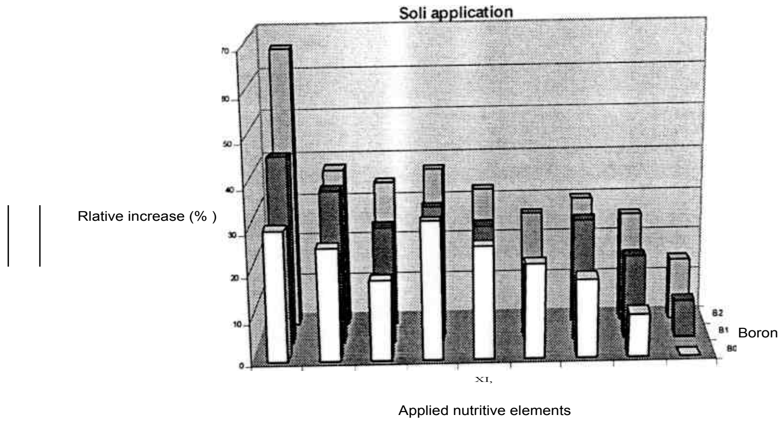
RESULTS AND DISCUSSION

N (mg/L)	Zn (mg/L)	B (mg/L)											
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.S.D. at 0.05		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RESULTS AND DISCUSSION



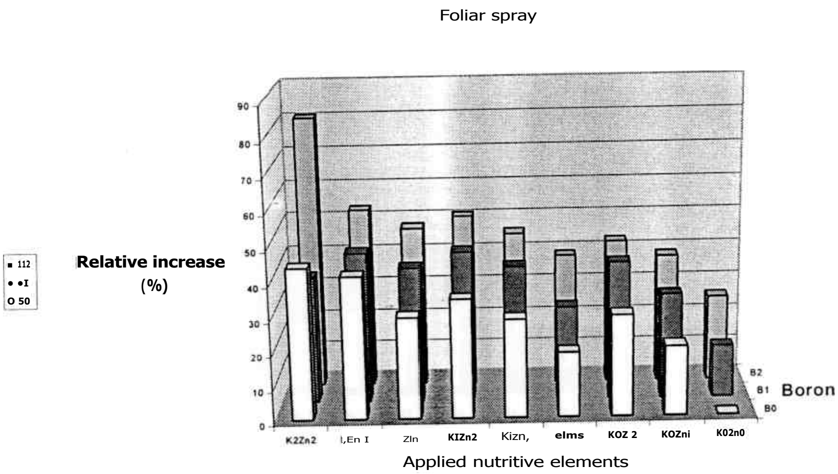
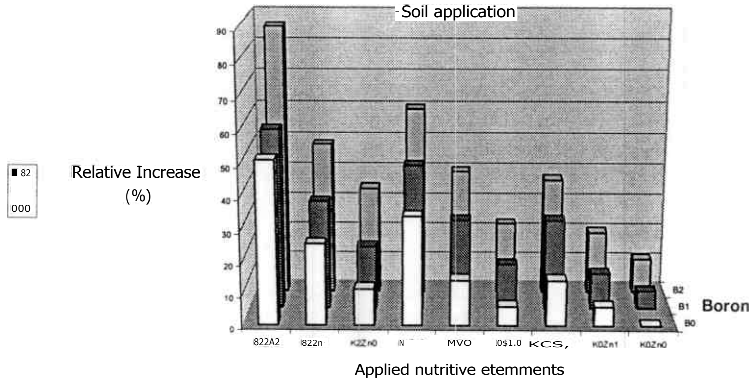


Fig. (4): Relative increase of N concentration (%) in sugar beet leaves after 100 days due to application of K, Zn and B at different rates.



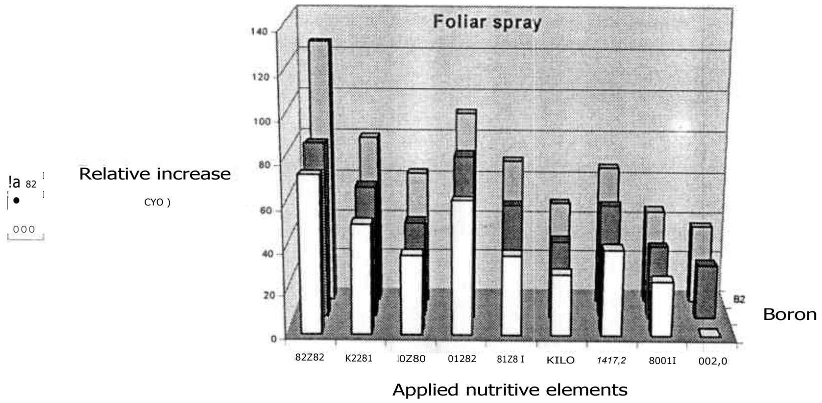
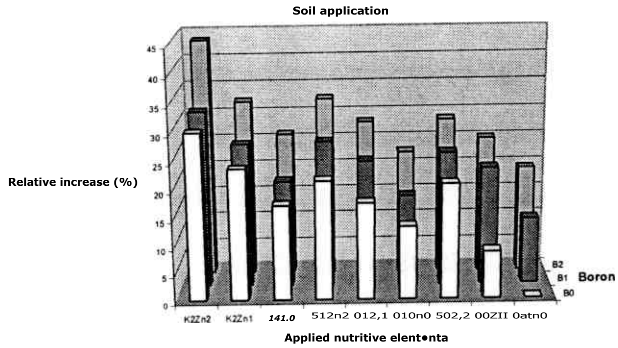


Fig. (5): Relative increase of P concentration (%) in sugar beet leaves after 100 days due to application of K,Zn and B at different rates.



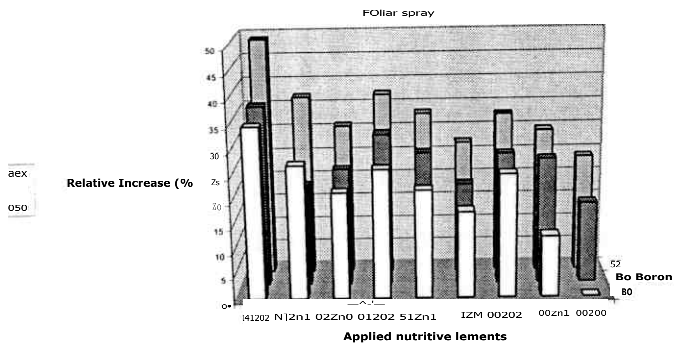


Fig. (6): Relative increase of K concentration (%) in sugar beet leaves after 100 days due to application of K, Zn and B at different rates.

The relative increases reached 14.6, 11.4 and 19.4 % for N, P and K, respectively, when K was applied alone at the rate of 40 kg/fed. The effect of K on increasing growth of sugar beet is emphasized by the results obtained by Abd El-Aziz *et al.* (1992) who showed that increasing K level was associated with increases in N, P and K contents of sugar beet tops. The increases in the content of these nutrients were also observed at any levels of applied B. Rizk *et al.* (1995) indicated that B application slightly affected the percentages of N, P and K, while the uptake of these nutrients was significantly increased by increasing the applied rates of B.

Abd El-Gawad *et al.* (2004) pointed out that solely and combined application of B and. Zn positively affected N and K contents in leaves of sugar beet were positively affected. They added that K % in leaves increased significantly due to the application of the highest Zn level as compared with the lowest one. Concerning the effect of Zn application on Zn content in sugar beet leaves, they mentioned that the obtained data did not reach a significant level.

Data also indicated that addition of K combined with Zn and B at the highest rates was more effective in increasing N, P and K in the leaves of sugar beet. The corresponding relative increases in the concentrations of N, P and K were 65.99, 85.71 and 43.36, respectively.

Also data presented in Table (7) reveal that addition of K as foliar spray at the highest rate (1000 mg K/L) alone increased the concentrations of N, P and K over the control treatment by 29.55, 37.14 and 21.50 %, respectively. Spraying sugar beet plants with Zn alone at the rate of 200 mg Zn/L increased the contents of N, P and K by 80.16, 125.71 and 48.74 %, respectively. Also, spraying sugar beet plants with B alone at the highest rate of 70 mg B/L increased N, P and K concentrations by 25.50, 37.14 and 24.01 %, over the control treatment, respectively.

Moreover, application of K, Zn and B together at the highest rates (1000 mg KJL + 200 mg ZIA + 70 mg B/L) as foliar spray gave the greatest increases in the concentrations of N, P and K in the sugar beet leaves. The corresponding relative increases were 60.32, 88.57 and 38.70 %, respectively.

These results indicated that the obtained N, P and K contents in sugar beet plants as a result of applied K, Zn and **B** fertilizers together as foliar spray surpassed those values when these fertilizers were applied as soil application, mainly due to the synergestic effect of K, Zn and **B,** which increased the uptake of N, P and K.

4.4. Yield of sugar beet (top and root) as affected by K, Zn and B application:

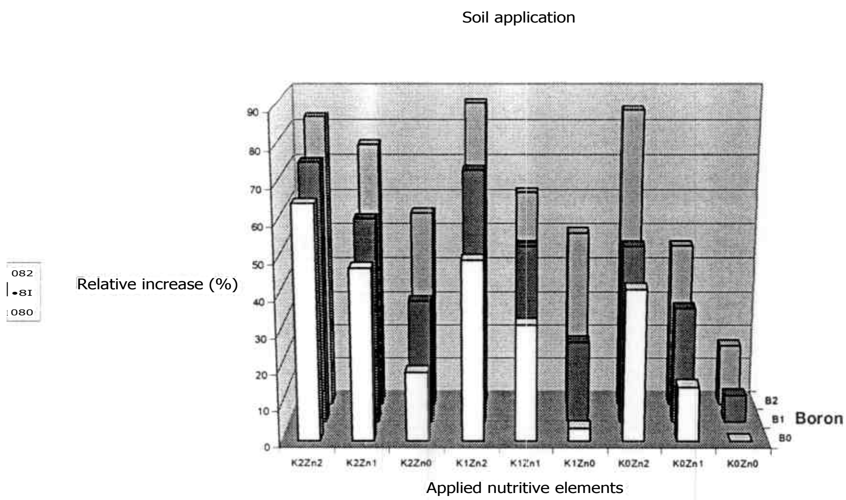
The effects of K, Zn and B fertilizers applied as soil application and foliar spray on sugar beet yield (top and root) are presented in Tables (8 and 9) and illustrated in Figs. (7 and 8). The obtained data show that addition of K fertilizer as soil application or foliar spray significantly increased top and root yields of sugar beet. Increasing K rate up to 40 kg K/fed as soil application increased top and root yields of sugar beet by 7.0 and 17.6 %, respectively. The corresponding relative increases were 14.6 and 25.5 % for top and root yieds, respectively, when K was applied as foliar spray at the rate of 1000 mg K/L. These increases in top and root of sugar beet due to K application may be attributed due to the pronounced increase in meristematic activity **(Osman, 2005).**

Table (8): Effect of K, Zn and B as soil application on sugar beet yield.

K (kg/fed)	Zn (kg/fed)	Top yield (ton/fed)				Root yield (ton/fed)			
		B (kg/fed)							
		0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
0	0.0	8.53	8.95	9.28	8.92	14.87	15.50	17.00	15.79
	35	8.85	9.19	9.58	9.20	16.27	17.62	18.49	17.46
	7.0	9.47	9.91	10.27	9.88	17.50	19.00	19.32	18.61
Mean		8.95	9.35	9.71	9.00	16.21	17.37	18.27	17.28
20	0.0	8.90	9.23	9.57	9.23	16.10	17.20	18.70	17.33
	35	9.30	8.95	9.97	9.60	17.38	18.66	19.57	18.54
	7.0	9.88	10.27	10.79	10.31	18.20	19.49	20.32	19.34
Mean		9.36	9.67	10.11	9.71	17.23	18.45	19.53	18.40
40	0.0	9.13	9.52	9.99	9.54	17.50	18.75	20.00	18.75
	35	9.63	10.10	10.45	10.06	18.42	20.00	20.69	19.70
	7.0	10.35	10.88	11.61	10.94	19.18	20.77	22.20	20.72
Mean		9.70	10.17	10.68	10.18	18.37	19.84	20.96	19.72
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		1.59	1.17	1.17	1.31	0.005	0.003	0.003	0.004
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		1.31	1.31	1.88		0.004	0.004	0.005	

Table (9): Effect of K, Zn and B as foliar spray on sugar beet yield.

K (mg/L)	Zn (mg/L)	Top yield (ton/fed)				Root yield (ton/fed)			
		B (mg/L)							
		ü 0	35	70	Mean	0.0	35	70	Mean
0	0.0	8.53	9.50	9.95	9.33	14.87	16.60	18.10	16.52
	100	9.48	9.85	10.26	9.86	17.40	18.72	19.67	18.59
	200	10.15	10.63	11.01	10.60	18.70	20.20	20.64	19.84
Mean		9.39	9.99	10.41	9.93	16.99	18.50	19.47	18.32
500	0.0	9.54	9.90	10.24	9.90	17.15	18.32	20.00	18.49
	100	9.96	10.21	10.68	10.28	19.50	20.00	20.97	20.15
	200	10.59	11.00	11.56	11.10	19.39	20.90	21.70	20.66
Mean		10.03	10.37	10.83	10.41	18.68	19.74	20.89	19.77
1000	0.0	9.78	10.20	10.71	10.23	18.66	20.16	21.40	20.07
	100	10.32	10.78	11.20	10.77	19.76	21.43	22.10	21.09
	200	11.10	11.60	12.40	11.71	20.52	22.17	23.57	22.08
Mean		10.40	10.86	11.45	11.12	19.64	21.25	22.35	21.08
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		0.37	0.003	0.003	0.004	0.37	0.37	0.37	0.04
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		0.004	0.004	0.005		0.04	0.04	0.06	



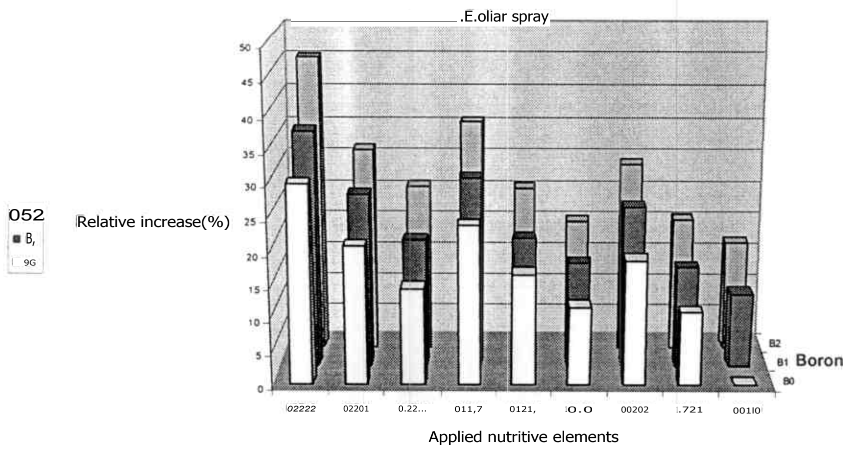
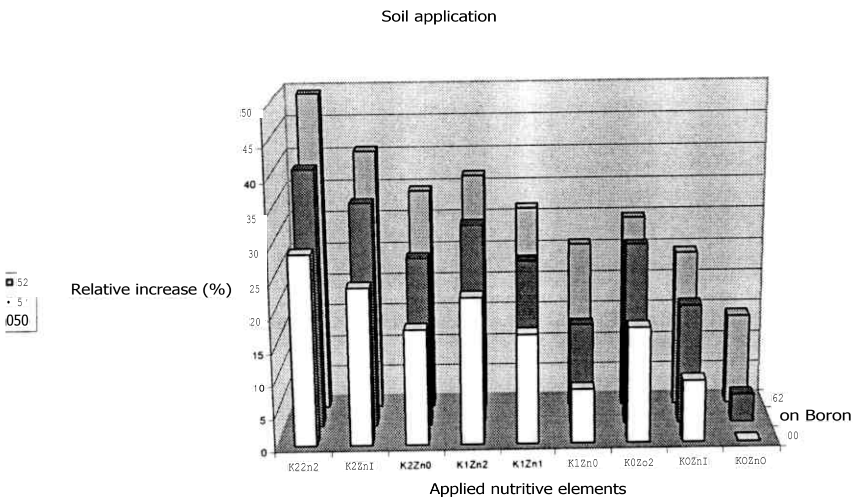


Fig. (7): Relative increase of top yield of sugar beet plant treated with K, Zn and B at different rates.



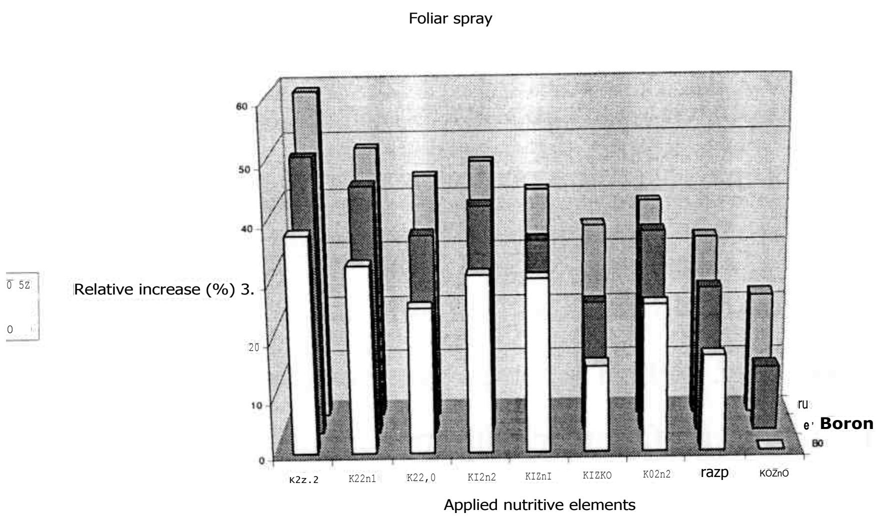


Fig. (8): Relative increase of root yield of sugar beet plant treated with K, Zn and B at different rates.

These results coincide with those obtained by **Osman (2005)** who showed that K fertilizer significantly increased top and sugar yields. The highest values of root and sugar yields were resulted due to application of K at a rate of 48 kg K20/fed. Similarly, **El-Shafi (1991)** reported that application of Zn fertilizer up to 4 kg Zn/fed to sugar beet plant significantly increased root fresh arid dry weights of top and root. Also, **Kristek *et al.* (2006)** found that application of B at a rate of 1 kg/ha gave maximum root yield (85.45 ton/ha) and sugar yield (11.12 ton/ha).

Concerning the interaction effect, **E1-Mashhadi (1988)** reported that application of potassium and boron fertilizers increased the percentage the total sugar yield. The best levels to increase total sugar yield was achieved by application of 48 and 1 kg/fed of K and **B,** respectively. **Abd E1-Aziz *et al.* (1992)** reported that increasing supply of K and B fertilizers as foliar or soil applications increased the dry weight of sugar beet. **El-Kased (1997a)** reported that addition of B improved the yield of fresh weight of sugar beet and the improvement was higher in the presence of Zn. Increasing the rate of **B** up to 3 kg/fed depressed both the yield and the vegetative growth of the plants.

With regard to Zn application in as soil application or foliar spray, the results showed that increasing the applied rates of Zn to the studied calcareous soil up to 7 kg/fed significantly increased top and root yields of sugar beet. The corresponding relative increases at the abovementioned highest rate of Zn were 11.0 % and 17.7 % for top and root yields of sugar beet, respectively, when compared with the control treatment.

Similarly, addition of Zn as foliar spray up to 200 mg Zn/L markedly increased top and root yields of sugar beet. The relative increases were 18.9 and 25.7 % for top and root, respectively, when compared with the control treatment. The increases in top and root yields due to the added Zn as either soil application or foliar spray may be attributed to increasing the metabolic activity of plant.

These results are in harmony with those obtained by **Genaidy (1988)** who showed that application of Zn as foliar spray was more effective in increasing top and root yields of sugar beet than soil application, presumable due to its higher uptake, whereas when Zn was added to calcareous soil most of Zn was fixed through precipitation in ZnCO3 form.

Saif Laaia (1991) mentioned that soil application of 4 kg Zn/fed gave the highest value of top fresh yield/fed. Also, **Saif (1991)** reported that soil application of 4 kg Zn/fed gave the highest values of top dry weights/fed. Moreover, **El-Shafi (1991)** reported that application of Zn-fertilizer at rates up to 4 kg Zn/fed to sugar beet plant gradually increased growth criteria, i.e., leaves number, top fresh and dry weights per plant and top dry matter. Also, a gradually and significant increase in root characters was obtained by increasing Zn application up to 4 kg Zn/fed, root fresh and dry weights per plant were significantly affected by Zn application.

Osman (1997) found that Zn applied at a rate of 3 kg/fed significantly increased root fresh weight. **El Kased (1997b)** found that application of Zn to sugar beet grown on a calcareous soil with marginal Zn availability, resulted in increased root and sugar yield, particularly when it was applied as foliar spray.

Data presented in Tables (8 and 9) also reveal that addition of B as soil application or foliar spray consistently increased top and root yields of sugar beet. However, increasing the applied rate of borax up to 3 kg/fed or B up to

5 mg/L significantly increased top and root yields of sugar beet. The corresponding relative increases for top and root of sugar beet reached 8.8 & 14.3 % for soil application and 16.6 & 21.7 % for foliar spray when the highest rates of both of them were applied, respectively. These variations were mainly attributed to applied B as foliar spray was easily taken up. Such findings are emphasized by those of **Bondok (1996)** who found that the addition of boron as foliar spray increased the yield with a percentage of 22.5 %.

It is clear that application of the highest rates of K, Zn and B as soil application or foliar spray, Tables (8 and 9), markedly and significantly increased top and root yields of sugar beet. The corresponding relative increases in top and root yields reached 36.1 and 49.3 % in the case of soil application vs 45.4 % and 58.5 % when K, Zn and B were applied as foliar spray, respectively. These data mean that, under the conditions of the current experiment, application of K, Zn and B together at the highest rates (600, 15 and 5 mg/L, respectively) as foliar spray were more effective in increasing top and root yields of sugar beet than addition as soil application.

4.5. Zn and B concentrations in sugar beet roots as affected by the applied K, Zn and B fertilizers:

Data in Tables (10 and 11) and Figs. (9 and 10) show that the addition of different rates of K, Zn and B to the studied calcareous soil as soil application or foliar spray caused a marked effect on Zn and B concentrations in sugar beet roots. It is clear that the addition of K, Zn and B as soil or foliar spray whether as solely or together resulted in increases in Zn and B concentrations in sugar beet roots. The corresponding relative increases in their concentrations at the applied K rate of 40 kg K/fed were 19.23 and 25.00 % over the control treatment, respectively.

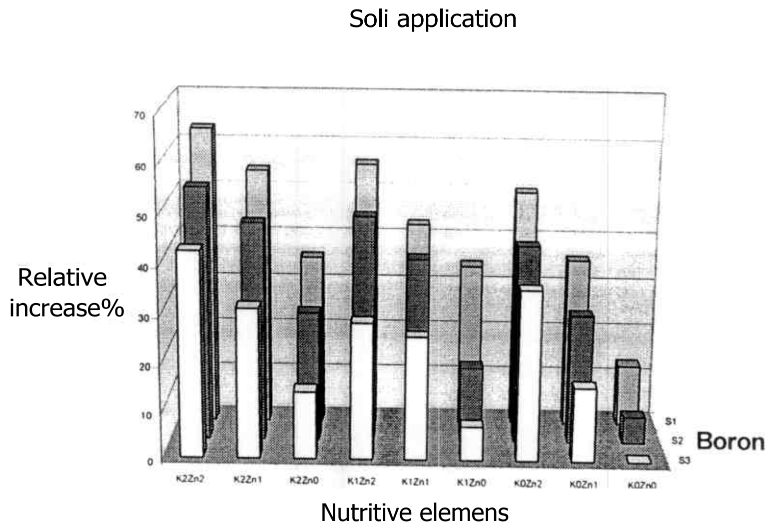
On the other hand, the relative increases in Zn and B concentrations when K fertilizer was applied at the rate of 600 mg/L as foliar spray were more than those found at the rate of 40 kg K/fed as soil application, where their relative increases were 14.28 and 26.10 %, respectively. This might be attributed to the more easily absorption of K as well as the effective role of applied K as foliar spray on enhancing the sugar beet plants to absorb more Zn and B.

Table (10): Effect of K, Zn and B as soil application on Zn and B concentrations in sugar beet roots.

K (kg/fed)	Zn (kg/fed)	Zn concentration (mg/kg)				B concentration (mg/kg)			
		B (kg/fed)							
		0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
0	0.0	52	56	61	56	40	47	56	48
	35	60	69	76	68	45	58	66	56
	7.0	74	78	85	79	61	73	82	72
Mean		62	68	74	68	49	59	68	59
20	0.0	54	64	78	65	48	57	60	55
	35	69	78	84	77	55	69	74	66
	7.0	78	89	97	88	73	84	99	85
Mean		67	77	86	77	58	70	77	69
40	0.0	62	70	81	71	50	58	62	57
	35	77	82	91	83	62	71	92	75
	7.0	86	90	95	90	93	98	106	99
Mean		75	81	89	82	68	76	87	77
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		2.11	1.89	1.89	2.11	3.11	3.58	3.58	4.00
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		2.11	2.11	3.04		4.00	4.00	5.76	

Table (11): Effect of K, Zn and B as foliar spray on Zn and B concentrations in sugar beet roots.

K (mg/L)	Zn (mg/L)	Zn concentration (mg/kg)				B concentration (mg/kg)			
		B (nig/L)							
		0.0	35	70	Mean	0.0	35	70	Mean
0	0.0	70	74	79	74	46	52	59	52
	100	81	89	95	88	54	63	71	63
	200	95	99	105	99	70	81	94	82
Mean		82	87	93	87	57	65	75	66
500	0.0	75	81	94	83	54	60	63	59
	100	88	97	100	95	63	74	85	74
	200	90	103	109	100	83	97	110	97
Mean		84	94	101	93	67	77	86	77
1000	0.0	80	89	95	88	58	66	72	65
	100	92	102	108	100	73	85	93	84
	200	100	107	114	107	99	115	125	113
Mean		91	99	106	98	77	89	97	87
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		2.11	1.89	1.89	2.11	3.11	3.58	3.58	4.00
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		2.11	2.11	3.04		4.00	4.00	5.76	



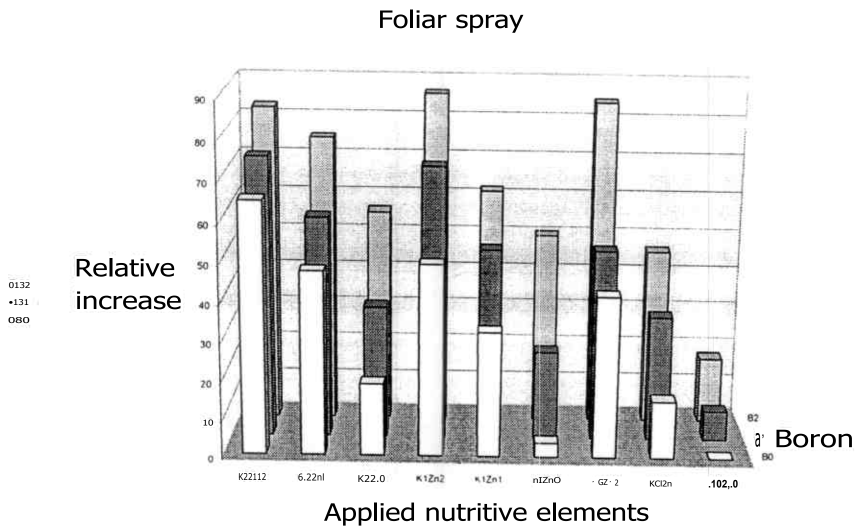


Fig. (9): Relative increase of Zn concentration (%) in sugar beet at harvest due to application of K, Zn and B at different rates.

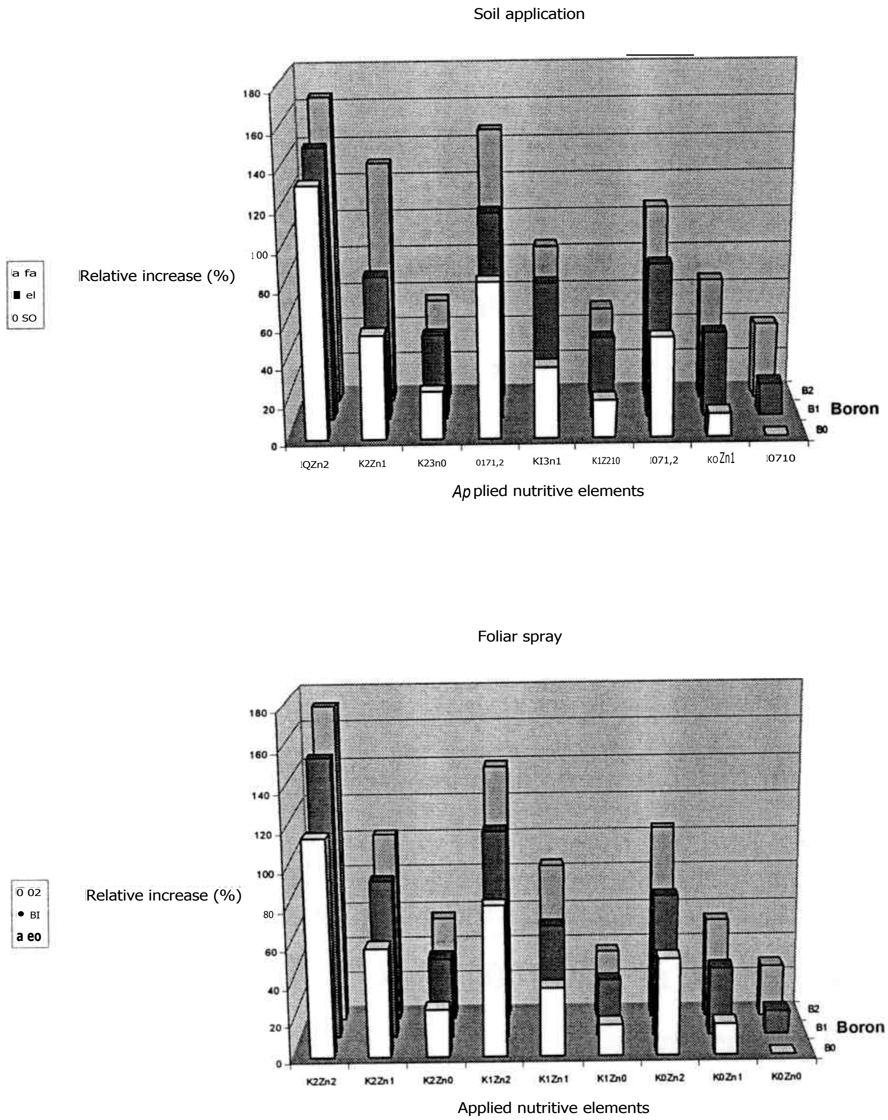


Fig. (10): Relative increase of B concentration (%) in sugar beet at harvest due to application of K, Zn and B at different rates.

These results are in accordance with those obtained by **Abd-El-Aziz *et al.* (1992)** who showed that increasing K level was associated with an increase in K content of roots of sugar beet. This increase in K content was also associated with an increase in B concentration. Moreover, **Omran *et al.* (2002)** reported that zinc and boron concentrations increased in sugar beet root by increasing the applied K rates.

In general, the highest values of each nutrient were obtained at the highest rates of applied K in combination with the highest rates of Zn and B. This was true, since the applied fertilizers of K, Zn and B when added as soil application (40 kg K/fed, 7 kg Zn/fed and 2 kg B/fed) resulted in relative increase percentages of 82.69 and 165.00 % for Zn and B, respectively, while, these increases were 62.85 and 171.70 % when the plants were sprayed with K, Zn and B at the rates of 1000 mg KIL, 200 mg Zn/L and 70 mg B/L, respectively.

Also, data showed that application of B to sugar beet plants grown on a calcareous soil, whether through soil application or foliar spray, gradually increased Zn and B concentrations in sugar beet roots.

The corresponding relative increases when B was applied at the highest rates as soil application and foliar spray (3.0 kg borax/fed and 5 mg B/L, respectively) were (17.30 & 70.00 %) and (12.80 & 28.30 %) for (Zn and B), espectively. These results agree along with those obtained by **E1-Shafei (1991)** who found that application of 0.5 kg B/fed resulted in a significant response for B content and uptake of top and root. Moreover, application of boron fertilizer significantly affected Zn content and uptake in both top and root at ages of 120 and 150 days. In this connection, **Wrobel (1997)** mentioned that boric acid application increased B content in sugar beet roots.

From the previous data, it is clear that addition of K in combination with Zn and B at the applied highest rates as foliar spray was more effective in increasing the sugar beet root concentrations of Zn and B than those attained when these elements were added as soil application. This might be attributed to the applied highest K, Zn and B rates as foliar spray enhancing the plants to absorb more Zn and B.

Moreover, **Domska (1996)** found that sugar beet given 100-140 kg N/ha added as soil application combined with 0.6 kg B/ha used as foliar spray gave the highest root content of both Zn and B. **Wrobel (1997)** studied the effect of some micronutrients fertilization including Zn and B on sugar beet yield and its contents of both nutrients. He found that the application of these micronutrients increased B and Zn contents in sugar beet roots.

4.6. N, P and K concentrationss in sugar beet roots as affected by the applied K, Zn and B fertilizers:

The results presented in Tables (12 and 13) and Figs. (11, 12 and 13) indicate that applied K as soil application or foliar spray was associated with pronounced increases in N, P and K concentrations. However, the magnitude of increment of these macronutrients differed from one nutrient to another, where the relative increases in their concentrations at the applied highest rates of soil application & foliar spray reached 17.74 & 25 %, 16.66 & 23.8 % and 17.64 & 24.26 % for N, P and K, respectively.

Data also showed that addition of B as soil application or foliar spray resulted in pronounced increases in the concentrations of N, P and K.

K (kg/fed)	Zn (kg/fed)	B (kg/fed)											
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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L.S.D. at 0.05			[illegible]		[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
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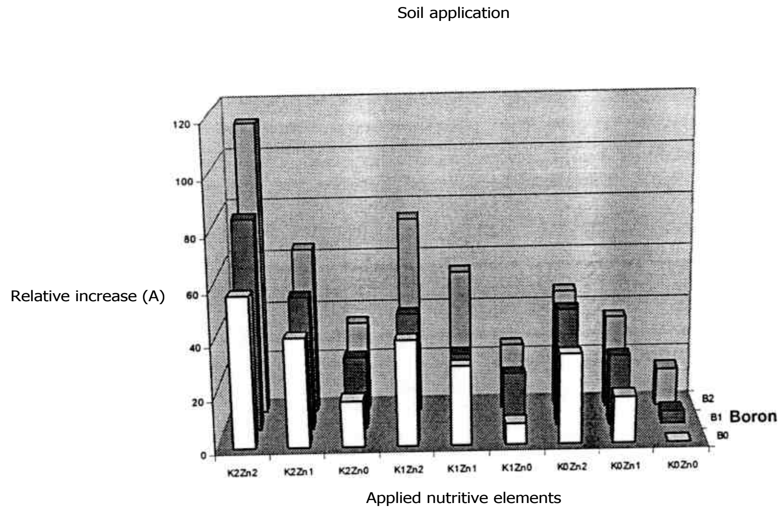
		[illegible]	[illegible]	KxZnxB		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	KxZnxB	
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	

RESULTS AND DISCUSSION

N (ʇnp/[,)	ZI1 (ʍO ɟ	N %				p %				N %			
		0	SE	OL	treajni	0.0	SE	OI	UDIAI	0.0	SE	C:	
.0	00	1Z1	8E	1.S0	LE'1	O 1'1	0.718	ICO	Lti0	1.36	1 S0	1 S9	O
	00	[illegible]	166	8C1	1.66	0.SZ	9C°	0.60	9C°	1.69	1 Z8	Cr	N
	00	1SC1	681	16	S8	6C°	0.6Z1	O S9	O 63	1 Z6	Z.O1	O	M
IVI		1S1	1.6'1	EL1	E9	Z£ 0	0*S6	6CO	0.SS	1.66			
S00		1t1	.S8	1.66	SS	0.718	O ES	0*S6	0.SZ	1.SS	EL1	00	O
		1.70	1.88	ZO7	1.81	8C0	0.671	0.69	0.671	1.86	Z06	N	6.1
	ON	88	1707	6Z7	Z.OS	0 U	0.69	LCO	0.69	Z.00	ZIE	un	N N
NN		S9	E8'1	1.99		0.S6	U 0	O 61	0.61	1.80	Z.00	N	
11000		SS'1	161	1.77	1.66	0.SZ	9C°	0.60	9C°	1.69	1.E8	Cr	8Z
	100	.58	861	Z1q	661	O 6Z	O 61		0.61	E07	LIZ	m	N
	O N	8	Z.9E	Z.61	1177	OCO	0.80	O V6	0.81	Z SZ	6S7	O	N
unvg		Z8'1	Z.00	EZ7	Z07	0.61	O 61	0.IS	0.68	1.99	Z.Z0	1717.7	Z C4
							UZ		x zn		zn	8	X Z
						E00 0	E00 0	O E00	1700.0	O E00	O E00	0.003	
		K x B				x	zn x	KxZnxB		1{ %	zn x		E}Xu
						0 00ᔭ	O 00ᔭ1	O S00		O 001	0.0071		S00

RESULTS AND DISCUSSION



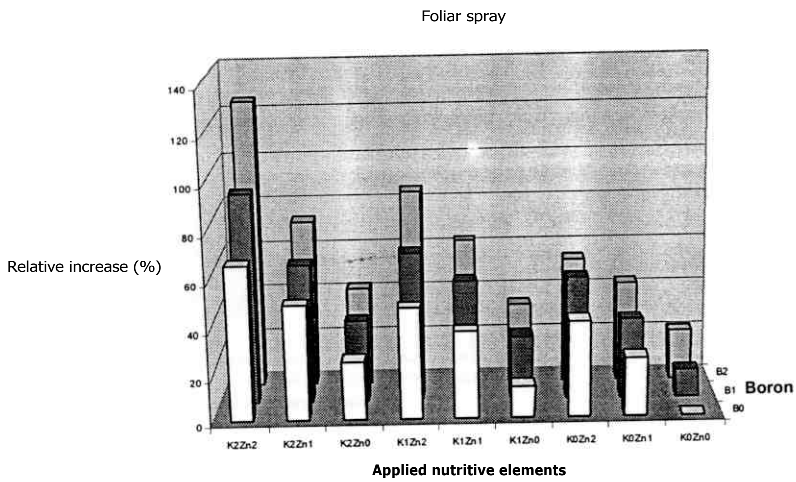
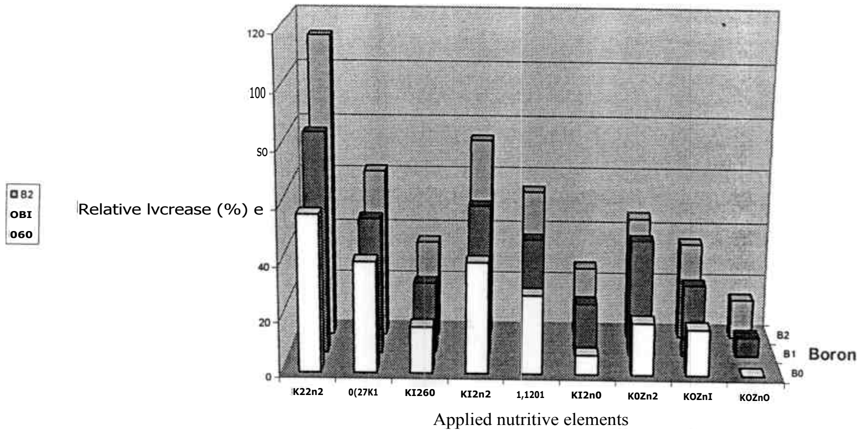


Fig. (11): Relative increase in N (%) in sugar beet root due to application of K, Zn and B at different rates.

Soil application



Foliar spray

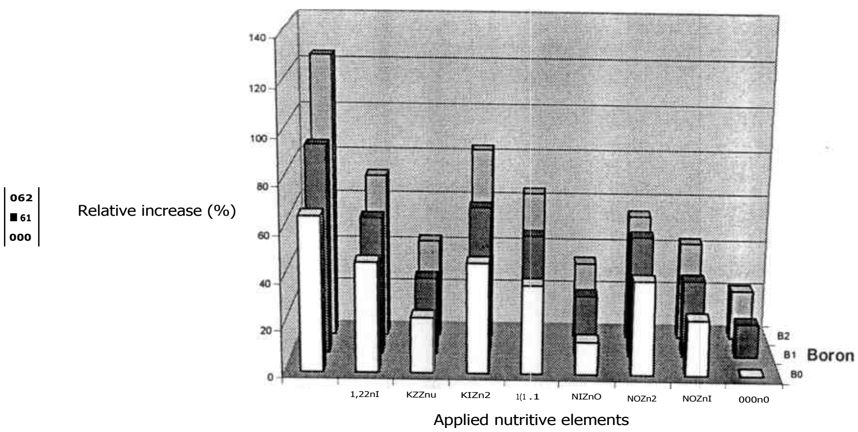


Fig. (12): Relative increase in P (%) in sugar beet root due to application of K, Zn and 13 at different rates.

Domska (1996) found that sugar beet given 100-140 kg N/ha added as soil application in combination with 0.6 kg B/ha used as foliar application gave the highest N and K contents. **Abuo-Elela (2006)** found that the application of boric acid was more effective for increasing the contents of N, P and K.

4.7. Diameter and length of sugar beet roots as affected by the applied K, Zn and B fertilizers:

Data in Tables (14 and 15) and Figs. (14 and 15) show that the addition of different rates of K, Zn and B alone or together to the studied calcareous soil as application or foliar spray caused marked positive effects on some growth parameters of sugar beet roots such as diameter and root length. The relative increases in root diameter and length at the applied K rate of 40 kg K/fed were 18.02 and 10.93 % over the control treatment, respectively.

On the other hand, the relative increases in root diameter and length when K fertilizer was applied at the rate of 600 mg/L as foliar spray were more than those found at the rate of 40 kg K/fed as soil application, where they achieved 24.46 and 17.30 %, respectively.

Table (14): Effect of K, Zn and B as soil application on diameter and length of sugar beet roots.

K (kg/fed)	Zn (kg/fed)	Root diameter (cm)				Root length (cm)			
		B (kg/fed)							
		0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
0	0.0	9.32	9.77	10.70	10.00	27.63	28.92	30.00	28.86
	3.5	10.00	10.90	11.63	11.00	29.30	30.15	30.45	29.97
	7.0	10.90	11.90	12.00	11.60	29.67	31.19	31.53	30.80
Mean		10.10	10.85	11.43	11.00	28.87	31.10	30.67	29.90
20	0.0	10.00	10.82	11.70	10.85	29.50	30.13	31.60	30.40
	3.5	10.80	1170	12.00	11.50	30.25	30.80	31.60	30.88
	7.0	11.40	12.20	12.70	12.10	30.35	31.30	32.45	31.37
Mean		10.70	11.60	12.12	11.50	30.00	30.74	31.88	30.89
40	0.0	11.00	11.80	12.50	11.80	30.65	31.49	31.92	31.35
	3.5	11.44	12.20	13.00	12.20	31.11	32.10	32.71	31.96
	7.0	12.00	13.00	13.65	12.90	31.50	33.12	33.81	32.81
Mean		11.50	12.33	13.50	12.00	31.10	32.22	32.81	32.00
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		0.03	0.01	0.01	0.01	0.26	0.26	0.26	0.29
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		0.01	0.01	0.01		0.29	0.29	0.42	

Table (15): Effect of K, Zn and B as foliar spray on diameter and length of sugar beet roots.

K (mg/L)	Zn (mg/L)	Root diameter (cm)				Root length (cm)			
		B (mg/L)							
		0	35	70	Mean	0.0	35	70	Mean
0	0.0	9.32	10.30	11.20	10.27	27.63	30.58	31.75	29.99
	100	10.40	11.25	12.30	11.32	30.15	30.85	32.15	31.10
	200	11.50	12.40	12.55	12.15	30.80	32.98	33.00	32.26
Mean		10.41	11.31	12.02	11.25	2.53	31.47	32.30	31.10
500	0.0	10.60	11.35	12.20	11.38	31.19	31.68	33.41	32.10
	100	11.48	12.19	12.45	12.00	31.95	32.53	33.80	32.76
	200	12.10	12.87	13.29	12.75	32.05	33.19	34.29	33.18
Mean		11.39	12.14	12.65	12.06	31.73	32.47	33.84	32.68
1000	0.0	11.60	12.30	13.10	12.33	32.41	33.29	33.75	33.15
	100	12.10	12.87	13.87	12.78	32.90	33.88	34.61	33.80
	200	13.11	14.04	14.53	13.90	32.28	34.31	35.74	34.11
Mean		12.27	13.07	13.67	13.00	32.53	33.83	34.70	33.78
L.S.D. at 0.05		K	Zn	B	KxZn	K	Zn	B	KxZn
		0.12	0.20	0.20	0.23	0.42	0.40	0.44	0.44
		KxB	ZnxB	KxZnxB		KxB	ZnxB	KxZnxB	
		0.23	0.23	0.33		0.44	0.44	0.64	

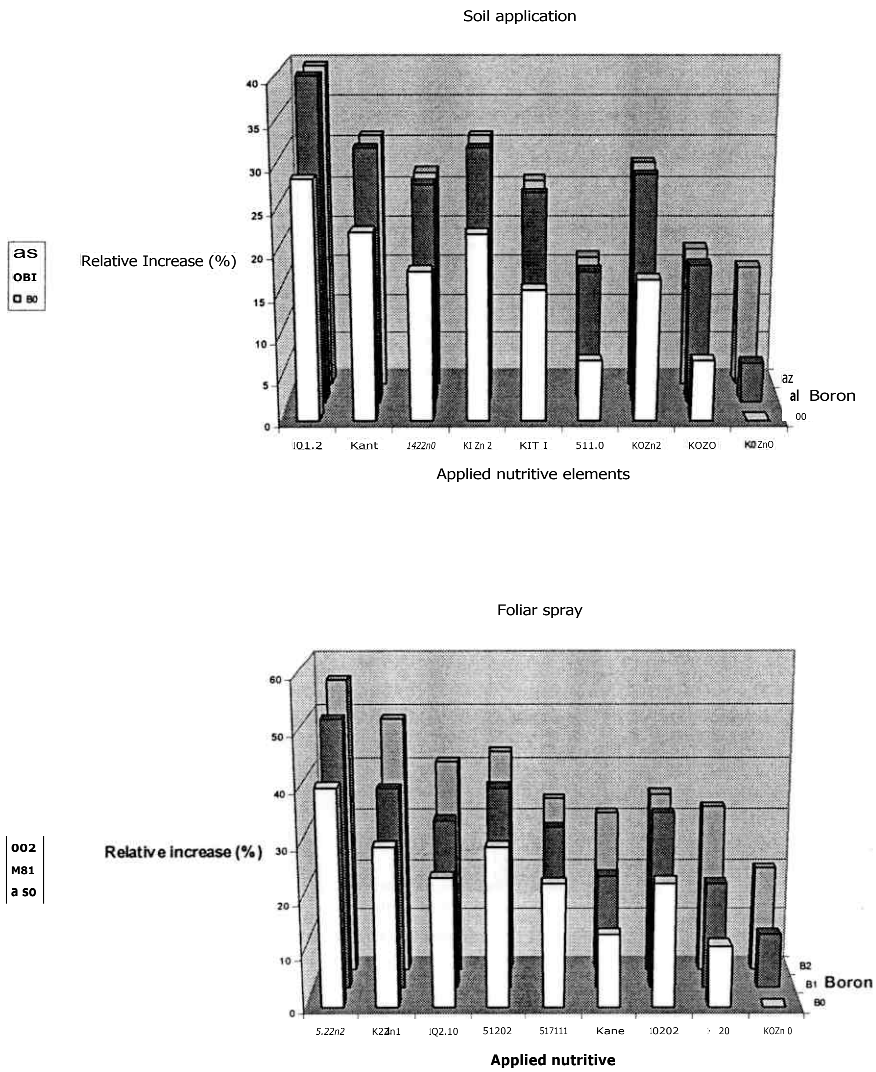


Fig. (14): Relative increase in root diameter of sugar beet plants due to application of K, Zn and B at different rates.

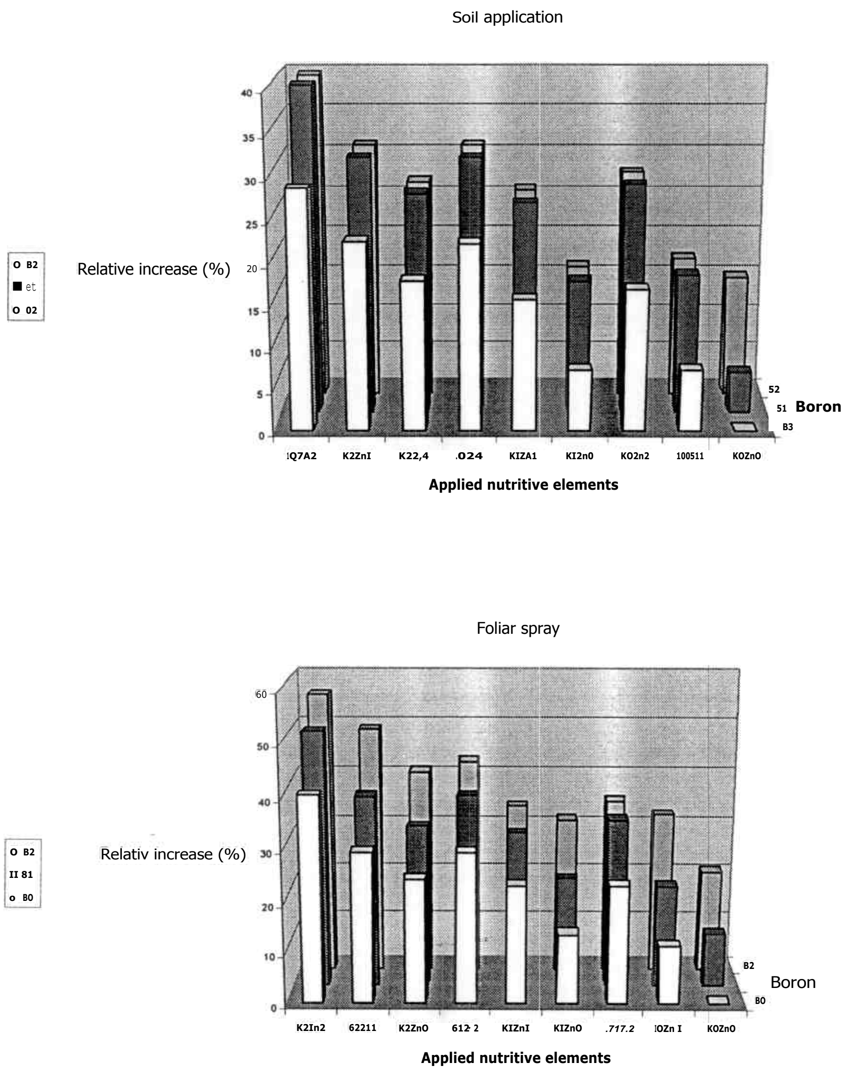


Fig. (15): Relative increase in root length of sugar beet plants due to application of K, Zn and B at different rates.

This might be attributed to the more easily absorption of K as well as the effective role of applied K as foliar spray on enhancing the root growth. These results are in harmony with those obtained by **Osman (2005)** who showed that addition of potassium fertilizer, which plays an important role in physiological processes of sugar beet plants, significantly increased root length and diameter. The highest values of root length and diameter were resulted from the applied rate of 48 kg K_20/fed. Concerning the effect of K as added in foliar spray, **Khafaga and Sallam (1999)** reported that K-foliar at different levels (1, 2 and 3 % KC1) improved root length and diameter with increasing K levels.

Results also show that addition of Zn as soil application alone at the different rates increased the root diameter and length of sugar beet. The relative increases resulted from applying 7 kg Zn/fed reached 16.95 and 7.38 % over the control treatment for root diameter and length, respectively. The corresponding increases were 23.39 and 11.47 % when the plants were sprayed with Zn at the rate of 200 mg Zn/L, respectively. This means that addition of Zn as foliar spray was more effective on root diameter and length than soil application.

This is mainly attributed to the stimulating effect of Zn on the root growth. In this connection, **El-Shafi (1999)** reported that application of Zn-fertilizer up to 4 kg Zn/fed to sugar beet caused a gradual and significant increases in root characters, i.e., diameter and length.

Also, data show that application of B to sugar beet plants grown on the calcareous soil under study, whether through soil application or foliar spray, gradually increased root diameter and length of sugar beet roots. The corresponding relative increases when B was applied at the highest rates as soil application and foliar spray (7 kg B/fed and 70 mg B/L, respectively) were (14.80 & 8.50 %) and (20.17 & 14.91 %) for (root diameter and length), respectively. These findings are in agreement with those undertaken by **Osman (1997)** found that application of B at the rate of 1 kg/fed significantly affected root length. Also, **Kristek *et al.* (2006)** concluded that the effect of B foliar spray positively affected sugar beet root yield and quality, whether applied B at a rate of 1 kg/ha gave the greatest root yield (85.45 ton/ha) and was prior to root quality.

In general, the highest values for each of root diameter and length of sugar beet were obtained at the highest rates of applied K in combination with the highest rates of Zn and B. This was true, since the applied fertilizers of K, Zn and B when added as soil application (40 kg K/fed, 7 kg Zn/fed and 2 kg B/fed) caused relative increases of 46.45 and 22.36 % for root diameter and length, respectively, while these increases were 55.90 and 29.35 % when the plants were sprayed with K, Zn and B at the rates of 600 mg K/L, 30 mg Zn/L and 5 mg B/L, respectively.

From the previous data, it is clear that addition of K in combination with Zn and B at the highest applied rates as foliar spray was more effective in increasing the root diameter and length of sugar beet than as soil application, probably due to foliar spray enhancing the growth and quality of sugar beet roots.

4.8. Sugar beet quality as affected by the applied K, Zn and B fertilizers:

The results obtained for the effect of K, Zn and B on the parameters of sugar beet quality, i.e., the percentages of total soluble solids (T.S.S), sucrose and purity are sited in Tables (16 and 17) and illustrated in Figs. (16, 17 and 18).

K (kg/fed)	Zn (kg/fed)	T.S.S. %				Sucrose %				Purity			
		B (kg/fed)											
		0.0	1.0	[illegible]	[illegible]	0.0	[illegible]		[illegible]	[illegible]			[illegible]
0	0.0	[illegible]	[illegible]	[illegible]	19.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3.0	[illegible]	[illegible]	[illegible]	19.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	7.0	19.88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	0.0	[illegible]	19.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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L.S.D. at 0.05			[illegible]	[illegible]	N		Zn	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
		0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	KxZnxB		[illegible]	[illegible]	KxZnxB		[illegible]	[illegible]	KxZnxB	
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	

RESULTS AND DISCUSSION

		T.S.S. % Sucrose % Purity °A											
		B (kg/fed)											
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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1000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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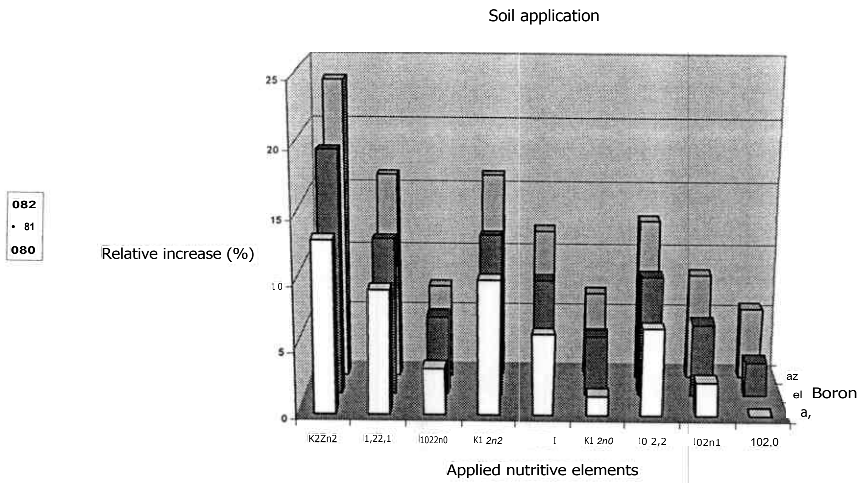
	[illegible]	[illegible]		[illegible]			[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L.S.D. at 0.05		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RESULTS AND DISCUSSION



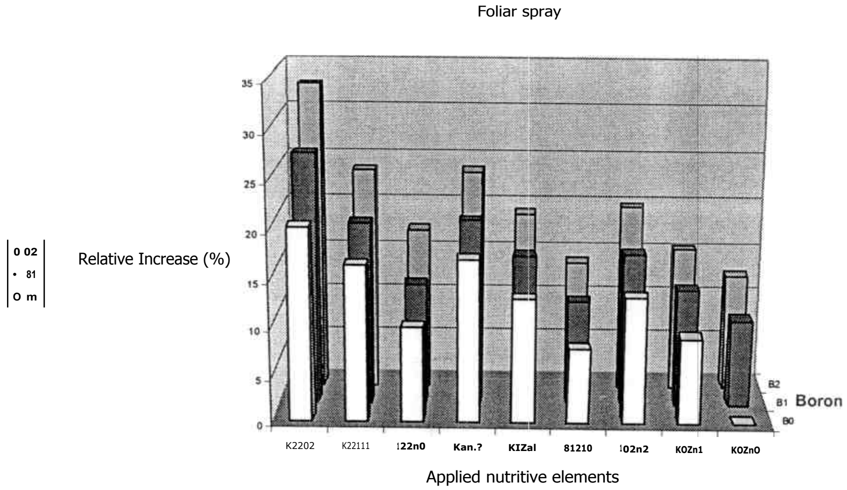
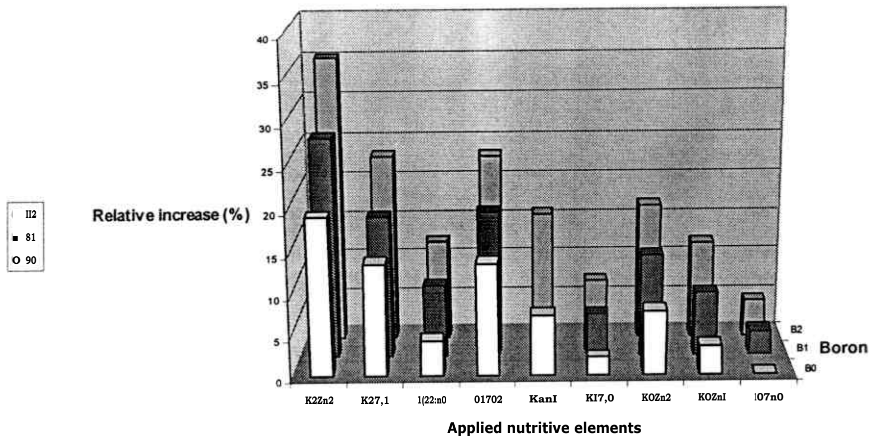


Fig. (16): Relative increase in T.S.S (%) of sugar beet due to application of K,Zn and B at different rates.

Soil application



Foliar spray

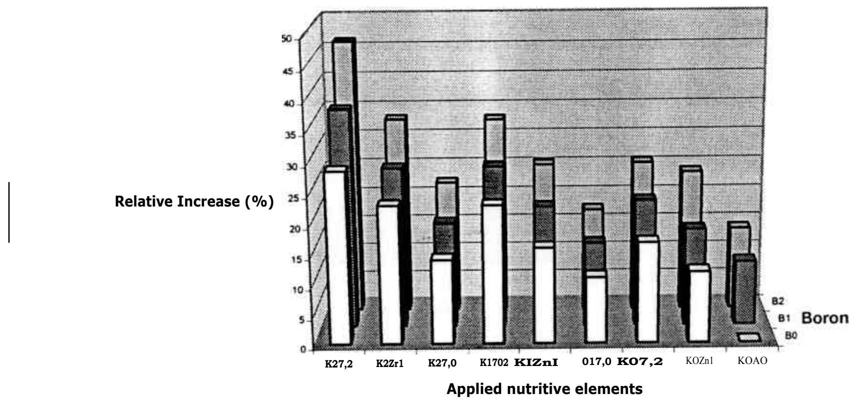
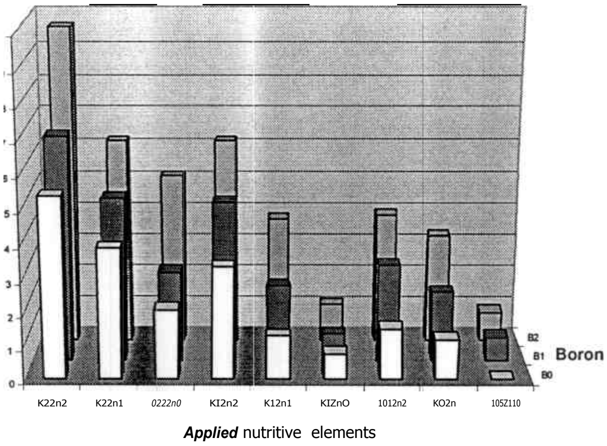


Fig. (17): Relative increase in sucrose (%) of sugar beet due to application of K, Zn and B at different rates.

Soil application



Foliar spray

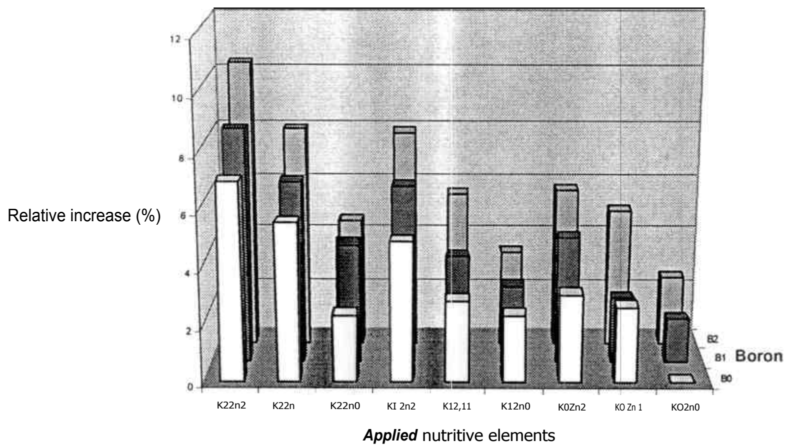


Fig (18) Relative increase in purity (%) of sugar •eet due to application of K, Zn and B at different rate

The data reveal that the values of T.S.S., sucrose % and purity % significantly increased due to application of K, Zn and B whether solely or together to the studied calcareous soil. Also, the same trend was observed when these fertilizers were applied as foliar spray.

However, increasing K rates from 0 up to 40 kg/fed was associated with an increase in each of T.S.S, sucrose % and purity %. Similar observation was also noticed when K was applied as foliar spray. The corresponding relative increases of T.S.S at the highest rate of K were 3.59 and 10.19 % when K was applied to soil and foliar sprayed, respectively.

The relative increase percentages over the control treatment for sucrose % were 4.31 and 14.02 % at the same order. Purity percentage also increased over control with application of K or K-sprayed by a bout 2.08 and 3.69 %, respectively. These results are confirmed with those obtained by **Osman (2001)** who found that foliar spray of sugar beet with 50 and 250 mg/L of K significantly improved the percentages of total soluble solids, sucrose and purity of sugar beet.

Also **Osman (2005)** showed that potassium fertilizer plays an the important role in physiological processes of sugar beet plants, where it significantly increased the percentages of total soluble solids, sucrose and purity. The highest values of sugar yields resulted due to the application of 48 kg K_20/fed.

Similarly, addition of Zn at the highest rate to soil or sprayed on plants increased markedly the abovementioned parameters of sugar beet quality, where the relative increases when Zn added as soil & foliar application were (6.85 & 3.46 %), (7.91 & 16.76 %) and (1.53 & 3.4 %) over the control treatment for T.S.S, sucrose % and purity %, respectively. These results are in agreement with those obtained by **Genaidy (1988)** and **Saif (1991)** who claimed that zinc fertilizer applied to sugar beet plant at a rate of 4 kg Z/fed increased sugar content, total soluble solids and juice purity in comparison to the control treatment.

In addition, application of B to the soil or sprayed on plants at the highest rate significantly increased T.S.S, sucrose % and purity % up to the greatest values.

The corresponding relative increases when B was applied as soil application (2 kg/fed) reached 5.68, 4.53 and 0.92 %, respectively. Also, the corresponding relative increases when **B** was sprayed at the highest rate (70 mg/L) were 12.39, 35.03 and 9.59 % at the same order.

These results are in harmony with those observed by **Bondok (1996) and Mahmoud (1999)** who found that the addition of boron at rates 250 and 2.5 g B/fed as soil application and foliar one, respectively, increased the yield and sucrose by about 4.5 and 0.5 ton/fed, with percentages of 22.5 and 15%. Also, **Hussein (2002)** found that highest root and sugar yields were obtained due to application of B at 6 mg/kg soil. In addition, application of B to the soil significantly increased total soluble solid and juice purity.

In this connection, **Omran** *et al.* **(2002)** and **Ibrahim (2006)** indicated that addition of Zn-B as soil and foliar application promoted the growth of sugar beet and produced the highest sucrose and sugar yield, with highest purity.

Moreover, application of K Zn and B combined together gave the greatest increases in T.S.S, sucrose % and juice purity %, especially at the highest rate.

The greatest increases in these parameters recorded at (40 kg K/fed + 7 kg Zn/fed + 2 kg B/fed). The relative increases were 23.39, 35.03 and 9.59 % for T.S.S, sucrose % and juice purity %, respectively. The corresponding relative increases in the case of foliar spray reached 32.67, 44.11 and 10.36 %, respectively. This means that the integrated effect of these nutrients at their highest rates, under the prevailing conditions of the current experiment, enhanced the plant growth, and consequently increased the values of T.S.S, sucrose % and juice purity %. Also, these beneficial effects may be attributed to the important role of both K and B, which increase the translocation of sugars.

Data obtained also reveal that addition of K, Zn and B either individually or together was more effective in increasing T.S.S, sucrose % and purity % in the case of foliar spray as compared with their addition in the form of soil application.

The corresponding relative increases when B was applied as soil application (2 kg/fed) reached 5.68, 4.53 and 0.92 %, respectively. Also, the corresponding relative increases when **B** was sprayed at the highest rate (70 mg/L) were 12.39, 35.03 and 9.59 % at the same order.

These results are in harmony with those observed by **Bondok (1996) and Mahmoud (1999)** who found that the addition of boron at rates 250 and 2.5 g B/fed as soil application and foliar one, respectively, increased the yield and sucrose by about 4.5 and 0.5 ton/fed, with percentages of 22.5 and 15%. Also, **Hussein (2002)** found that highest root and sugar yields were obtained due to application of B at 6 mg/kg soil. In addition, application of B to the soil significantly increased total soluble solid and juice purity.

In this connection, **Omran *et aL* (2002)** and **Ibrahim (2006)** indicated that addition of Zn-B as soil and foliar application promoted the growth of sugar beet and produced the highest sucrose and sugar yield, with highest purity.

Moreover, application of K, Zn and B combined together gave the greatest increases in T.S.S, sucrose % and juice purity %, especially at the highest rate.

The greatest increases in these parameters recorded at (40 kg K/fed + 7 kg Zn/fed + 2 kg B/fed). The relative increases were 23.39, 35.03 and 9.59 % for T.S.S, sucrose % and juice purity %, respectively. The corresponding relative increases in the case of foliar spray reached 32.67, 44.11 and 10.36 %, respectively. This means that the integrated effect of these nutrients at their highest rates, under the prevailing conditions of the current experiment, enhanced the plant growth, and consequently increased the values of T.S.S, sucrose % and juice purity %. Also, these beneficial effects may be attributed to the important role of both K and B, which increase the translocation of sugars.

Data obtained also reveal that addition of K, Zn and B either individually or together was more effective in increasing T.S.S, sucrose % and purity % in the case of foliar spray as compared with their addition in the form of soil application.

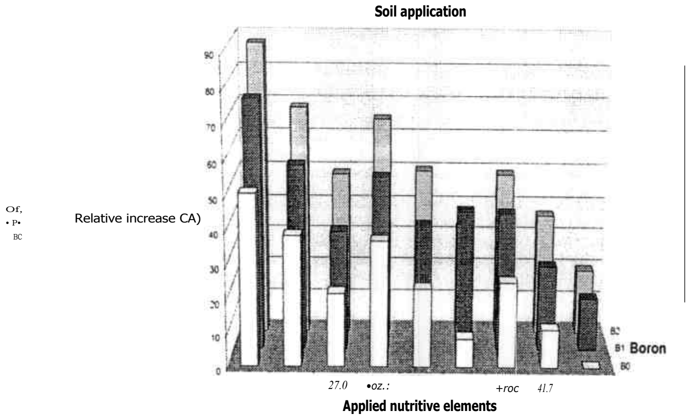
4.9. Sugar yield as affected by K, Zn and B application:

Effects of different rates of K added either alone or combined with Zn and B under two methods of application on sugar yield (ton/fed) are given in Table (18) and illustrated in Fig. **(19).**

Table (18): Effect of K, Zn and B as soil application and foliar spray on sugar yield.

K (kg/fed)	Zn (kg/fed)	Soil application B (kg/fed) 0.0	1.0	2.0	Mean	x (ƙ w,	(Tau) UZ	Foliar spray B (mg/L) 0.0	35	70	Mean
0	0.0	2.10	2.22	2.51	2.26	0	0.0	2.10	2.57	2.89	2.51
	3.5	2.34	2.63	2.87	2.61		100	2.70	3.02	3.30	3.01
	7.0	2.63	2.97	3.13	2.91		200	3.03	3.40	3.62	3.35
Mean		2.34	2.61	2.84	2.60	Mean		2.60	3.00	3.27	2.95
20	0.0	2.28	2.52	2.78	2.53	500	0.0	2.62	2.89	3.21	2.91
	3.5	2.59	2.89	3.15	2.88		100	3.14	3.34	3.65	3.38
	7.0	2.88	3.19	3.47	3.18		200	3.31	3.69	4.01	3.67
Mean		2.58	2.87	3.13	2.86	Mean		3.02	3.31	3.62	3.32
40	0.0	2.56	2.85	3.13	2.85	1000	0.0	2.96	3.29	3.64	3.30
	3.5	2.91	3.26	3.54	3.24		100	3.36	3.78	4.08	3.74
	7.0	3.17	3.66	3.94	2.59		200	3.67	4.21	4.78	4.22
Mean		2.56	2.85	3.13	2.85	Mean		3.33	3.76	4.17	3.75
L.S.D. at 0.05		K	Zn	B	K.Zn	L.S.D. at 0.05		K	Zn	B	K.Zn
		0.04	0.06	0.06	0.07			0.06	0.05	0.05	0.05
		K.B	Zn.B	K.Zn.B				K.B	Zn.B	K.Zn.B	
		0.07	0.07	0.10				0.05	0.05	0.08	

Data indicate that application of K, Zn and B added alone or together had a marked effect on sugar yield (ton/fed). However, increasing K fertilizer added as soil application and foliar spray alone up to 40 kg K/fed and 1000 mg K/L, respectively consistently



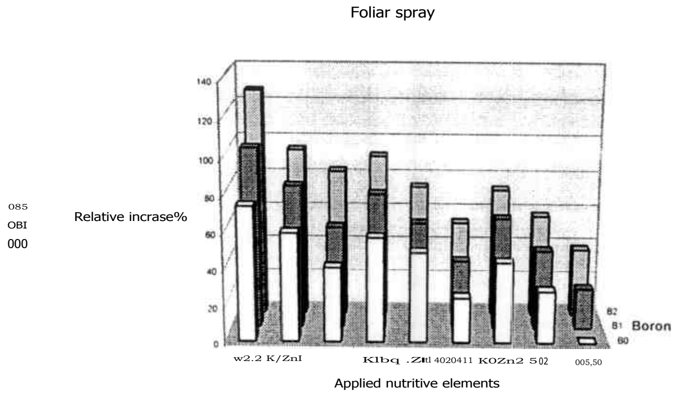


Fig. (19): Relative increase in sugar yield of sugar beet due to application of K, Zn and B at different rate increased sugar yield (ton/fed). The greatest amount of sugar yield was recorded at the highest rates of K either applied to soil (40 kg Klfed) or sprayed on plants (1000 mg K/L). The corresponding relative increases were 21.9 and 40.95 %, respectively.

Potassium as foliar spray was more effective for increasing of sugar yield as compared with soil application. These increases are mainly attributed to enhancing in the growth of sugar beet yield due to addition of K as soil application and foliar spray as a result of its role in physiological processes in plant. These results are in harmony with those obtained by **Ibrahim (1998) and El-Taweel (1999)** who found that increasing K application from 0 to 24 and 48 kg K_20/fed significantly increased weight of sugar yield of sugar beet plants.

Similarly, addition of Zn as soil application and foliar spray to the studied calcareous soil increased sugar yield of sugar beet. The best treatment was achieved in the case of applied Zn at the rate of 7 kg Zn/fed and 200 mg Zn/L as soil application and foliar spray, respectively.

The corresponding relative increases in sugar yields were 25.23 and 44.28 %, respectively. These relative increases may be due to the lower shift of soil pH in the case of soil application, presumable owing to application of Zn in the form of sulphate beside the role of Zn in physiological processes These results are in agreement with those obtained by many authors such as **Fathi *et al.* (1983)** who found that plant yield increased by mineral application of $ZnSO_4$. Data also reveal that addition of Zn as foliar spray was more effective in increasing sugar yield, probably due to its easily absorption and translocation as well as the physiological role of Zn in plant growth.

Moreover, addition of B as soil application and foliar spray increased sugar yield. The treatments 2 kg B/fed and 70 mg B/L were the best treatments. The corresponding relative increases were 19.52 and 37.61 %, respectively. In this connection, **El-Kased (1997b)** found that application of Zn plus B as foliar spray to sugar beet grown on a calcareous soil resulted in an increase in sugar yield. Also, data showed that addition of B as foliar spray was more effective in increasing sugar yield than that addition as soil application.

Moreover, addition of K at different rates in combination with Zn or B either as soil application or foliar spray gave the highest increases in sugar yield. The greatest sugar yield was, generally, obtained at the highest applied rates of these fertilizers. The relative increase in sugar yield due to soil application of (K + Zn + B) at the highest rates reached 87.61 % over the control treatment.

The corresponding relative increase in the case of foliar spray was 127 %. This is mainly ascribed to increase the availability of K, Zn and B as essential nutrients for plant growth. It could be concluded that the growth of sugar beet grown on a calcareous soil was enhanced by the application of K in combination with Zn and B at the highest rates. This was true, since such nutrients were applied as foliar spray.